

## Claims

We claim:

- 1 1. A model stored in a memory describing a transcoded video, comprising:  
2 a first rate-distortion function modeling a requantization of an input video  
3 corresponding to the transcoding video;  
4 a second-rate distortion function modeling a resynchronization marker  
5 insertion rate for the transcoded video; and  
6 a third rate-distortion function modeling an intra-block insertion rate for the  
7 transcoded video.
- 1 2. The model of claim 1, further comprising:  
2 a bit allocation control module configured to receive the input video and  
3 allocating bits to the transcoded video according to outputs of the first, second, and  
4 third models.
- 1 3. The model of claim 1, in which the first function outputs a quantization  
2 parameter, the second function outputs the resynchronization marker insertion rate,  
3 and the third function outputs the intra-block insertion rate.
- 1 4. The model of claim 1, in which inter-frame dependencies in the transcoded video  
2 are due to a requantization distortion in a current frame of the transcoded video that  
3 is propagated to a next frame of the transcoded video through motion compensation,  
4 and further comprising:  
5 the first model is modified for the next frame to account for propagating the  
6 requantizing distortion.

1 5. The model of claim 4, in which the input video has a first bit rate greater than a  
2 second bit rate of the transcoded video.

1 6. The model of claim 5, in which the distortion  $D$  is expressed as

$$D = \left[ \prod_{i=0}^{L-1} \Phi(\omega_i) \right]^{1/L} \cdot e^{-\beta \cdot R(D)},$$

2  
3 where  $L$  is a total number of frequency coefficients of a discrete cosine transform in  
4 the input video,  $\Phi(\omega_i)$  is a power spectrum density function of coefficient  $i$ ,  $R$  is the  
5 second bit rate, and  $\beta$  is  $2\ln 2$ .

1 7. The model of claim 6, in which  $\beta$  is a variable,  $R(D)$  is replaced by  $R^\gamma(D)$ , where  
2  $\lambda$  is a Lagrange multiplier, and  $[\prod_{i=0}^{L-1} \Phi(\omega_i)]^{1/L}$  is replaced by a variance  $\sigma^2$ , so  
3 that the distortion is

$$D = \sigma_k^2 e^{-\beta R^\lambda(D)}.$$

1 8. The model of claim 7, in which  $\beta$  is in a range of  $[1, 10]$ , and  $\gamma$  is in a range of  $[0,$   
2  $1]$ , so that the distortion is

$$D_0 = \sigma_0^2 e^{-\beta_0 R_0^{\gamma_0}},$$

3  
4 where  $D_0$  is a distortion of an intra-coded frame of the transcoded video caused by  
5 the requantization, and  $R_0$  is the first bit rate.

1 9. The model of claim 8, further comprising:

2 means for estimating  $\beta$  and  $\gamma$  from two sample points on the rate-distortion  
3 functions.

10. The model of claim 8, in which the allocating operates on groups-of-frames of the transcoded video to account for inter-frame dependencies in the input video due to a requantization distortion in a current frame of the output video that is propagated to a next frame of the output through motion compensation, and further comprising:

means for changing the variance  $\sigma_k^2$  to  $\sigma_k^{*2}$  to model the inter-frame dependency, and a distortion of requantized inter-frames is

$$D_k = \sigma_k^{*2} e^{-\beta_k R_k^r} = (\sigma_k^2 + \alpha_k D_{k-1}) e^{-\beta_k R_k^r}, \quad k = 1, 2, \dots, N - 1,$$

where  $\sigma_k^{*2} = \sigma_k^2 + \alpha_k D_{k-1}$ , and  $D_k - 1$  denotes a quantization residue error produced when a previous frame of the input video is requantized with a larger quantization-scale,  $\alpha_k$  denotes a propagation ratio, which is determined by an amount of motion compensation, and  $\alpha_k D_{k-1}$  models the inter-frame dependency between the current and the previous frame.

11. The model of claim 1, in which the bits allocated for inserting the resynchronization markers is determined from a number of bits in a resynchronization header and a resynchronization marker spacing, and the bits allocated for inserting the intra-blocks is determined from an intra-block insertion rate and an average rate increase by replacing inter-coded block with intra-blocks.